U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

Commission Briefing: Overview of Advanced Reactor Fuel Activities

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Office of Nuclear Energy

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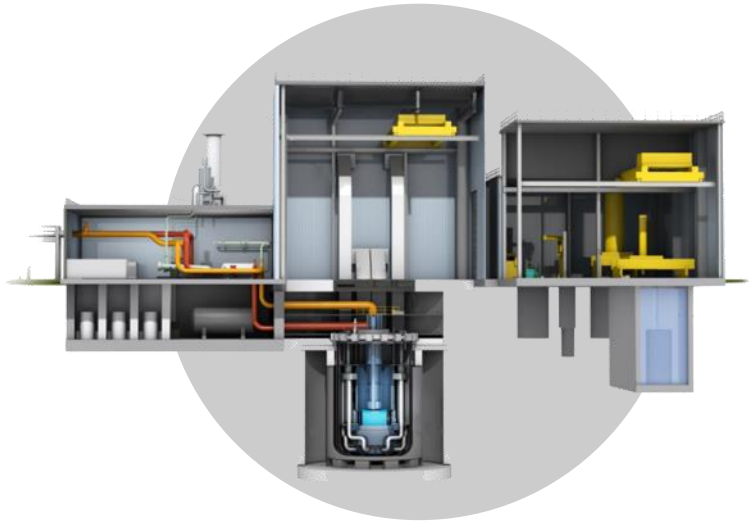
Agenda

- Top Priorities: Advanced Reactor Development
- Advanced Reactor Fuel R&D to Support Industry
- High-Assay, Low-Enriched Uranium
- Summary

Top Priorities: Build Advanced Reactors

1 DEMONSTRATION — **GOAL:** *Test, license and build operational reactors within 5 - 7 years.*

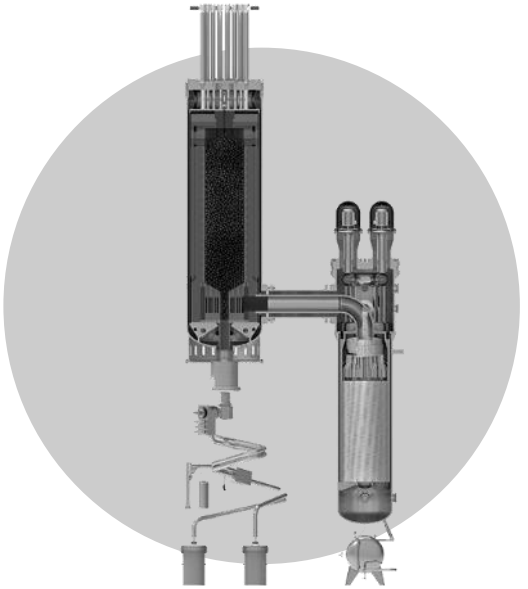


Natrium Reactor

Sodium-cooled fast reactor + molten salt energy storage system

TERRAPOWER

Kemmerer, WY



Xe-100

High-temperature gas reactor

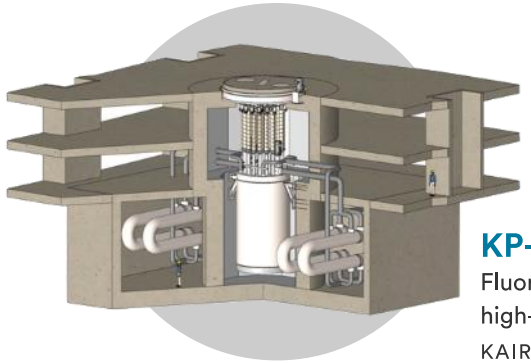
X-ENERGY

Grant County, WA

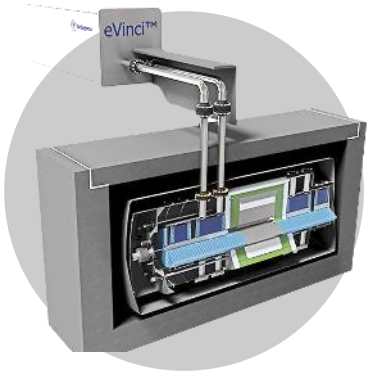
Top Priorities: Build Advanced Reactors

2 RISK REDUCTION

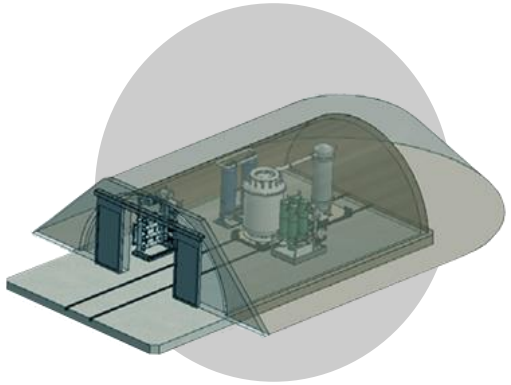
GOAL: *Solve technical, operational and regulatory challenges to support demonstration within 10 - 14 years.*



KP-FHR
Fluoride salt-cooled high-temperature reactor
KAIROS POWER

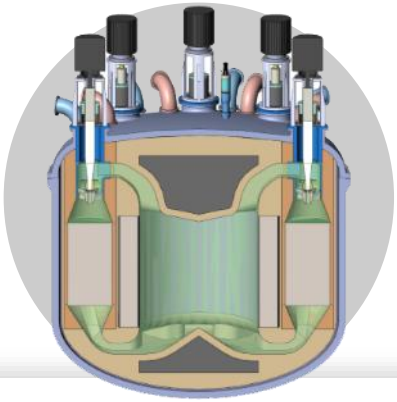


eVinci
Heat pipe-cooled microreactor
WESTINGHOUSE NUCLEAR



BWXT Advanced Nuclear Reactor (BANR)
High-temperature gas-cooled microreactor
BWX TECHNOLOGIES

SMR-160
Advanced light-water small modular reactor
HOLTEC INTERNATIONAL

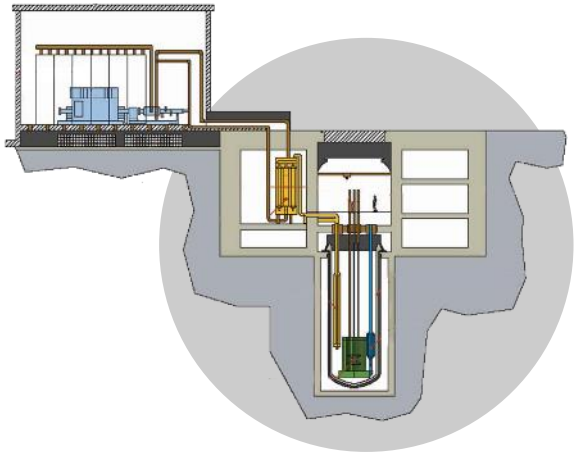


Molten Chloride Fast Reactor
SOUTHERN COMPANY

Top Priorities: Build Advanced Reactors

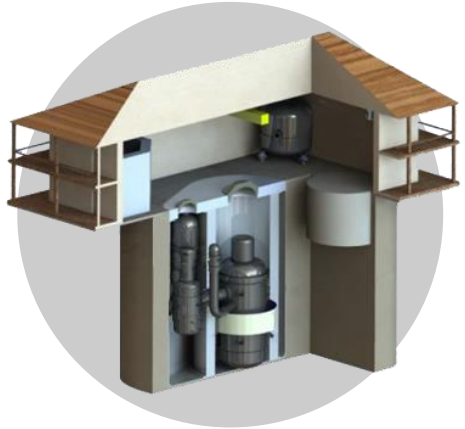
3 CONCEPT DEVELOPMENT

GOAL: *Solidify concept to mature technology for potential demonstration by mid-2030s.*



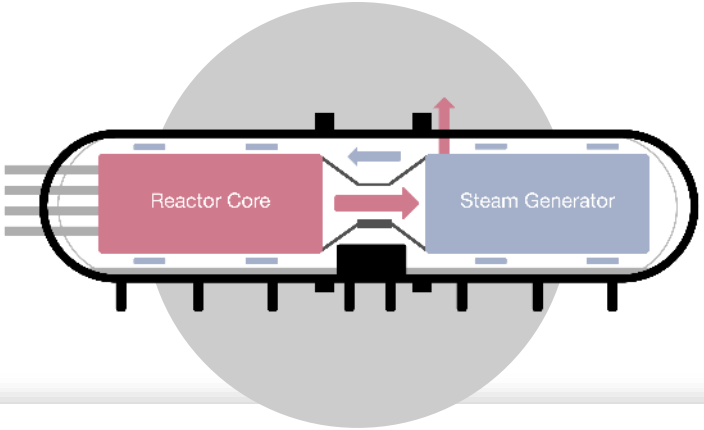
Advanced Sodium-Cooled Reactor Facility

ADVANCED REACTOR CONCEPTS



Fast Modular Reactor

GENERAL ATOMICS

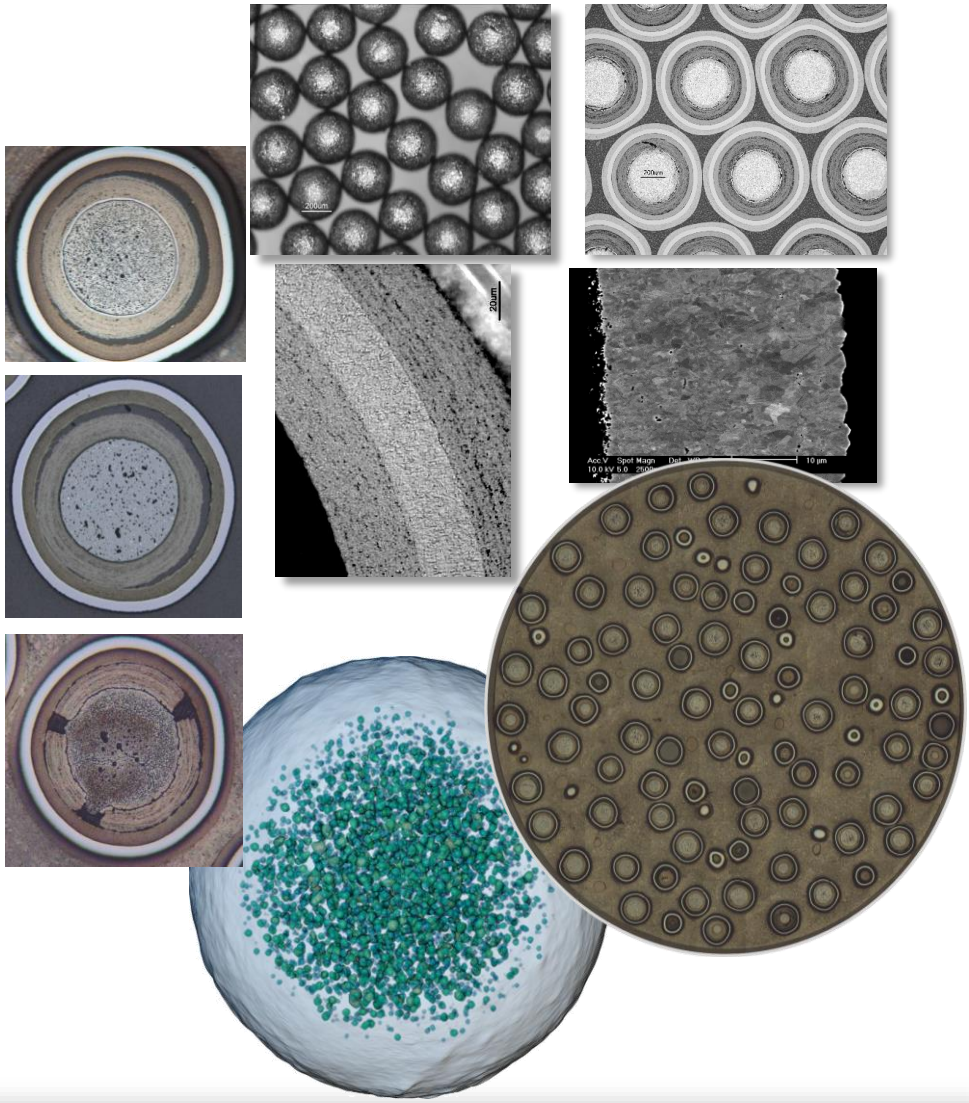


Horizontal Compact High-Temperature Gas Reactor

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

TRISO Fuel – Many Designs Leveraging Deep Investments

- DOE has invested over $400M in the TRISO and graphite qualification programs
  - Advanced gas reactor (AGR) fuel qualification program has performed fabrication, irradiation, post-irradiation examination (PIE), and safety testing on TRISO particle fuel since 2002.
  - Tested to 1800°C – exhibits low levels of particle failure and maintains excellent fission product retention
  - Average fuel burnup that is approximately 4 times higher than existing reactors and significantly improves overall economics
  - Excellent long-term robustness which provides excellent spent fuel containment after use
  - Collaborated with Electric Power Research Institute (EPRI) on a Topical Report which has been endorsed by the NRC (ML20336A052) and is reducing regulatory risks for high temperature designs planning to use this fuel type
- **TRISO fuel has been selected** for several **high temperature reactor designs**
- **DOE is continuing PIE on irradiated fuel to quantify fission product retention characteristics and fuel performance in response to varying reactor fluence and temperature, support source term determinations, and provide experimental data required to support future commercial fuel fabrication activities.**



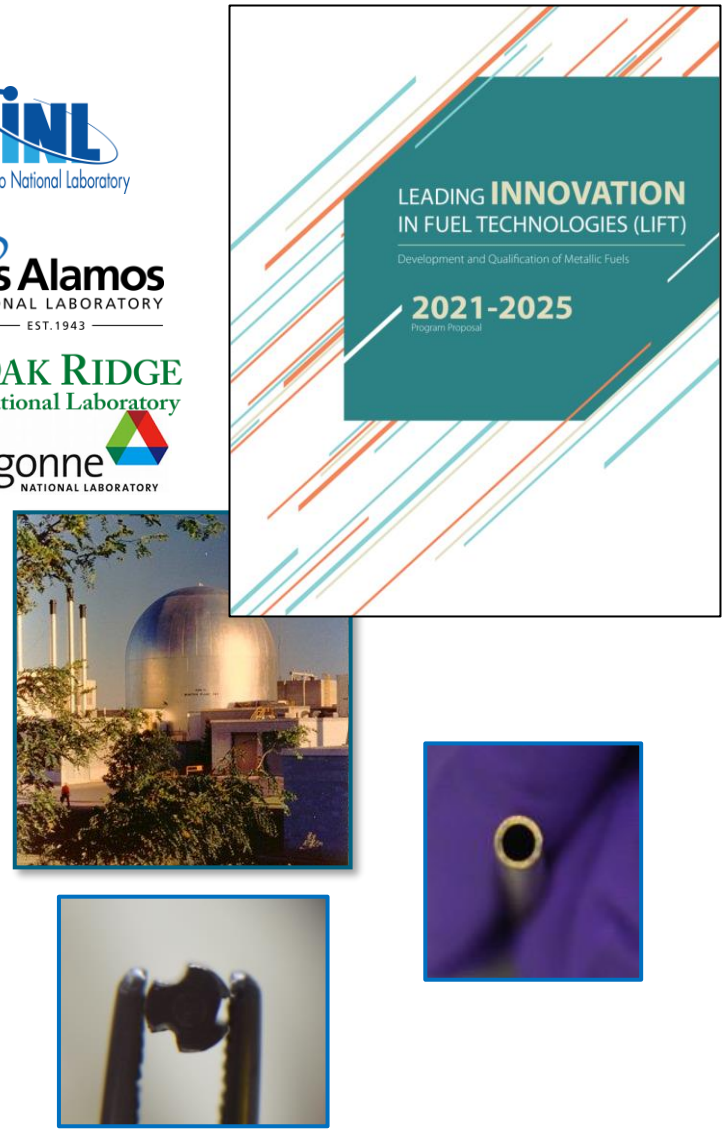
Metallic Fuel

LIFT – *Leading Innovation in Fuel Technology*

- **Goal: Perform R&D to support qualification of metallic fuel technology to enable advanced reactor deployment and development**
  - Use TRISO fuel qualification as inspiration
  - Reduce risk for market entry

- **Objectives:**
  1. Establish reference fuel performance basis for U-10Zr/HT9 using legacy R&D and modern tools to fill gaps

  2. Innovate metallic fuel design using accelerated techniques to maximize fuel applications and performance potential
     - **5 years** – Develop & demonstrate accelerated fuel qualification to deliver Na-free metallic fuel option

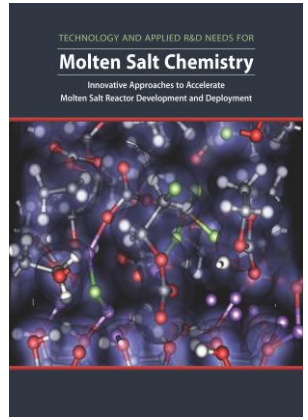


Molten Salt Fuels Development

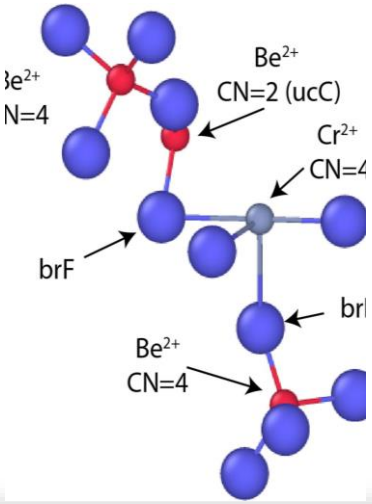
- **Legacy of solid fuel development data, models, platforms, and tools has limited utility for developing molten salt fuels.**
- **Establishing cross-cutting, multidisciplinary teams at national labs and universities to support molten salt fuel R&D:**
  - Developing salt preparation, recycling and purification methods
  - Characterizing and understanding salt structure and property relationship
  - Developing in-situ measurements for salt systems
  - Filling salt data gaps and developing atomic level models to predict salt properties and behaviors
  - Utilizing computer simulations and machine-learning approaches to accelerate the salt fuel developments

UCl_3-RbCl melt at 850°C

UCl_4-CsCl melt at 750°C

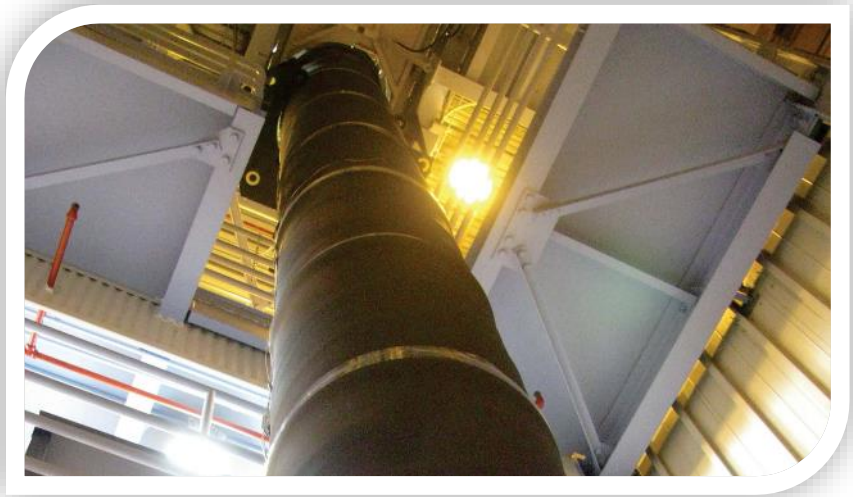


https://www.ornl.gov/content/molten-salt-chemistry-workshop



HALEU

HIGH-ASSAY LOW-ENRICHED URANIUM



- $45M FY 2022 Enacted
- $95M FY 2023 Request
- $700M Inflation Reduction Act
- Only commercial scale supplier is TENEX in Russia

WHAT IS IT?

Uranium enriched between

5% AND 20%

in uranium-235—the main fissile isotope that produces energy during a chain reaction.

Low-Enriched Uranium
<20% U-235
- Existing Reactors (up to 5%)

HALEU
5%-19.75% U-235
- Advanced Reactors
- Nuclear Thermal Propulsion Rockets

Highly-Enriched Uranium (HEU)
≥20% U-235
- Naval Reactors (>90%)

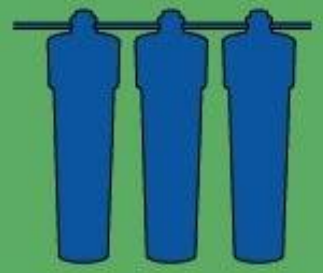
ALLOWS FOR...

- Smaller Designs
- Longer Life Cores
- Increased Fuel Efficiency
- Less Waste

HOW IT'S MADE

Chemical Processing
Recycle used government-owned HEU and downblend to HALEU.

Enrichment
Gas centrifuges separate uranium isotopes by weight to produce a higher percentage of U-235 in the uranium.



HALEU: Energy Act and Inflation Reduction Act

Energy Act of 2020, Section 2001

A. Criticality benchmark data
B. Design and license transportation packages
C. NRC certification

D. Consider options for DOE acquisition
E. Biennial survey
F. Establish consortium
G. Cost recovery
H. Establish capability to acquire/provide HALEU

Inflation Reduction Act

- $100 million for A-C
- $500 million for D-H
- $100 million for support activities

- Remains available through September 30, 2026.

- To the maximum extent practicable, use a competitive, merit-based review process.

Summary

- One of NE's highest priorities is to support the deployment of advanced reactors.
- NE is supporting industry with the R&D needed to qualify advanced reactor fuel.
- Many advanced reactor developers are taking advantage of NE's investment in TRISO fuel development.
- NE is working to do the same with metallic fuel and molten salt fuel.
- Most advanced reactors need high-assay, low-enriched uranium and NE is working to establish a diverse, US-based, commercial HALEU market.

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